

# Reduction in carbon uptake during turn of the century drought in western North America

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## Objectives:

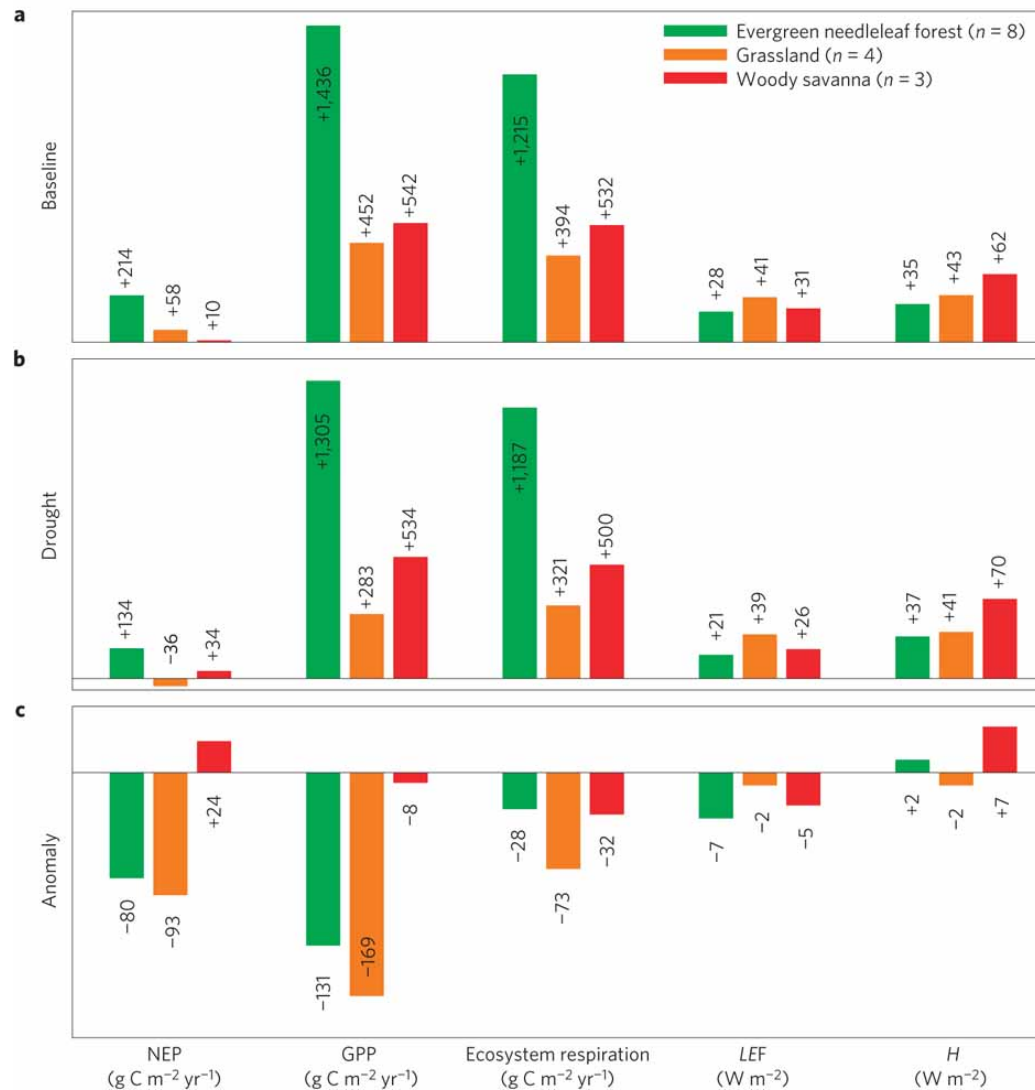
- The primary objective of this study was to examine the effect of the turn of the century drought (2000-2004) in western North America on carbon uptake in the region.
- The findings were then compared with previous paleoclimate reconstructions to determine the relationship of the turn of the century drought to past droughts.
- The findings were also used for a forward look at the dynamics of the mid-latitude carbon sink in western North America, based on projected changes in precipitation and drought severity.
- In order to determine the effect of drought on carbon update, the authors used reanalysis data, remote sensing observations and data from global monitoring networks.

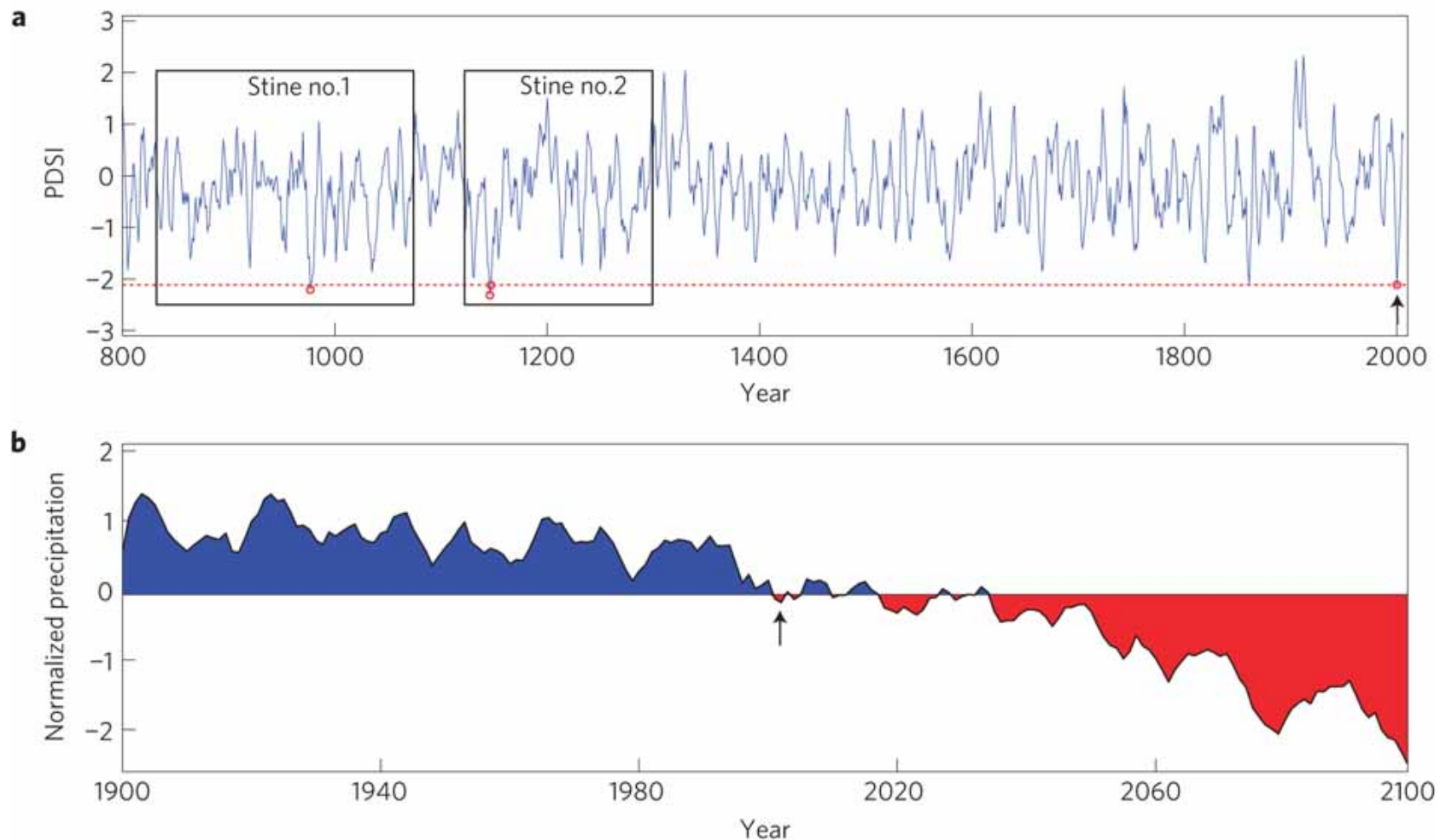
## New Science:

- The turn of the century drought in western North American was the most severe drought over the past 800 years, significantly reducing the modest carbon sink normally present in this region.
- The turn of the century drought reduced expected annual net CO<sub>2</sub> uptake by, on average, 51% (full range 5% - 168%), and the area-integrated strength of the western North American carbon sink declined by 30-298 Tg C yr<sup>-1</sup>.
- Only two drought events of similar severity occurred from 800 to 1200 - this was from 977 to 981 and from 1146 to 1151. Both of these were the most severe periods during historical megadroughts. These megadroughts persisted longer and affected smaller regions than the turn of the century drought.
- Over the past 2,000 years, only 97 single-year summer PDSI values were as or more severe than the 2000-2004 drought event.
- Projections suggest that this drought will become the wet end of a drier hydroclimate period in the later half of the twenty first century.
- These drought events are projected to persist for most of the present century as the first megadrought of the instrumental era.
- Based on projected changes in precipitation and drought severity, we estimate that the present mid-latitude carbon sink of 177-623 Tg C yr<sup>-1</sup> in western North America could disappear by the end of the century.

## Significance:

- Temperate North America is presently a net sink of carbon dioxide, when fossil fuel emissions are set aside.
- Year to year variations in the carbon sink are linked to variations in hydroclimate that affect net ecosystem productivity, and drought is a significant variation, particularly extreme events.
- From 2000-2004 western North America (25°-50°N, 100°-125°W) experienced a protracted drought.
- This drought led to a clear reduction in water availability as indicated by decreased runoff in all major water basins of the western United States, and in a decrease in productivity (5%) in 2,383 counties of the western United States.
- During this period, carbon uptake was suppressed at 10 of 15 eddy-covariance flux tower sites from the global FLUXNET network and micrometeorological stations also recorded decreased latent heat flux (LE) for each of the three land-cover classes.
- Drought effects in the study region also included water and carbon balances, based on anomalies recorded for precipitation, soil moisture, instrumental era PDSI, MODIS net primary productivity (NPP) and empirically upscaled FLUXNET data.
- Precipitation projections indicate the conditions of the turn of the century drought will become the new norm in western North America.





**Figure 4: Drought over western North America from 800 to 2100.**

**a**, Reconstructed summer PDSI from 800 to 2006, five-year mean. Black rectangles show Stine no. 1 and Stine no. 2 mega droughts. Red circles denote five-year drought events as severe as the turn of the century event. Red line denotes the mean PDSI during the 2000–2004 event ( $-2.11$ ). **b**, Normalized CMIP5 summer precipitation from 1900 to 2100, five-year mean. Horizontal line denotes the turn of the century drought severity. Red and blue shading shows dryness more or less severe, respectively, than the turn of the century drought. Arrows indicate the turn of the century drought.